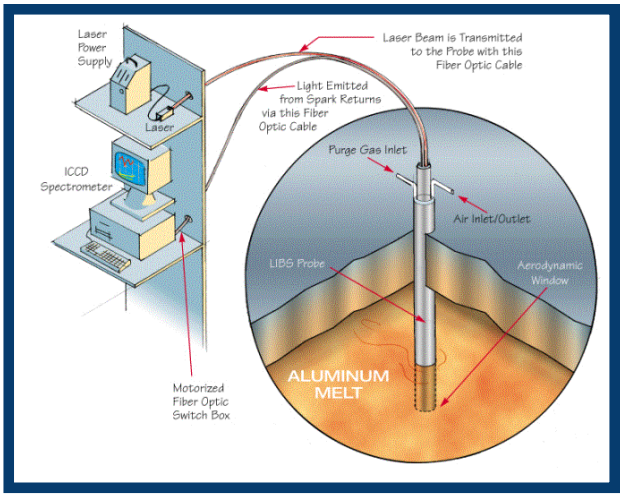
In-Situ, Real-Time Measurement of Melt Constituents

Laser-Induced Breakdown Spectroscopy (LIBS) Provides Real-Time Analysis of Elemental Constituents to Improve Product Quality

The new LIBS system from the Energy Research Company (ERCo) offers an inexpensive way to measure the composition of molten metal and glass, in-situ and in real time. Designed, constructed, and successfully implemented by ERCo with funding from the Department of Energy, the innovative system is now streamlining operations at project partner Commonwealth Aluminum's facility in Uhrichsville, Ohio. The technology is currently available commercially to aluminum, glass, and steel manufacturers looking to modernize their processes, and may have applications in mining and other processing industries.

During the production of secondary aluminum from scrap sources such as aluminum cans, composition must be closely controlled to ensure that final properties meet customer specifications. Because the composition can only be adjusted while the material is in a molten state, current practice is to remove a small sample of molten material from the furnace for analysis off-line. This approach is expensive and time-consuming, leading to excessive processing, quality control difficulties, increased energy use and emissions, and off-spec product that may need to be reprocessed.

The new LIBS technology employs a laser to measure, in-situ and in real time, the constituents of the melt in a process furnace. This approach represents a significant advance in the state of the art in composition determination, not only for process control but also for determining the degree of alloying, mixing, density segregation, contamination, and the behavior of transient elements. Major benefits include improved product quality and increased productivity through faster furnace cycle times, which can actually lead to semi-continuous or even continuous operation of formerly batch processes. The technology can also enable furnace automation by providing data for modeling and simulation of furnace operations.



Schematic of the laser-ultrasonic system

Benefits for Our Industries and Our Nation

The LIBS probe provides in-situ, real-time measurement of melt constituents and temperature with a system costing between $65,000 and $250,000, depending on the application. The system offers annual energy reductions of 5 to 10 trillion Btus per year across the aluminum, glass, and steel industries. The probe enables manufacturers to eliminate furnace idle time due to off-line measurements and reduces product rejections resulting from variations in melt composition.

Applications in Our Nation's Industries

The primary target applications for the LIBS system are in the aluminum, glass, and steel industries. In the glass industry, the technology is especially suited for monitoring of trace alkali metal content in electronic glasses and monitoring the composition of waste-vitrified glasses and sealing glasses. Applications in the aluminum and steel industries include monitoring metal composition during alloying; facilitating semi-continuous and continuous furnace operations by minimizing off-line sampling and measurement; in-line monitoring the removal of impurities from the melt; and validation of computer simulation and modeling of furnaces with real-time data.

Project Summary

Objective:

The project objective was to design, construct, and test a new sensor capable of measuring the elemental constituents of molten substances in-situ and in real time. Major accomplishments included lab-scale and pilot-scale testing of an instrument capable of measuring the elemental constituents of molten aluminum, the design and construction of a probe compatible with the harsh aluminum processing environment, the development of software to eliminate the need for calibration, and the long-term test of the complete system in a commercial aluminum plant. The project has been completed successfully, with installation resulting in a permanent, commercially operating, continuous measurement system.

Technology:

The LIBS technology employs a laser and a spectrometer to measure, in-situ and in real time, the constituents of the melt in a process furnace. A probe is placed inside the melt, and a laser is fired repetitively through a fiber-optic cable and through the probe. A small amount of melt at the probe tip absorbs the laser light, producing temperatures sufficiently high to heat and vaporize the melt sample into a gaseous plasma state. The resulting plasma emits a signal that is detected and sent to the spectrometer. This characteristic signal is spectrally resolved to uniquely identify the elements in the melt and the concentration of each element present.

Major innovations in the LIBS technology, which include fiber optical probes, the optical layout, and calibration-free software, combine for a rugged instrument that is well-suited for the production floor. The system is designed to be a single push-button operation with no training required. The operator presses the on button and, if all the interlocks are satisfied, the probe automatically extends into the melt and begins collecting data. Similarly, a single button ends the measurement and retracts the probe. The LIBS system is self-calibrating and is certified as eye-safe. No specialized training in operation or safety is needed, and no special safety equipment is required.

Project Milestones:

This project was selected through the Sensors and Controls Program FY 1999 solicitation and was awarded in January 1999. Key tasks and milestones met were:

- First probe designed and constructed 1999
- First probe lab-tested 2000
- System upgraded 2001 and 2002
- Confirmation of calibration-free software 2003
- Testing at Commonwealth Aluminum initiated 2003

Commercialization:

The LIBS technology has been installed on a full-scale commercial operation at Commonwealth Aluminum and continues to operate at this facility. The sensor is available commercially worldwide from ERCo (www.er-co.com/rd_laser.htm), which handles engineering support, instrument development, instrument fabrication, and maintenance services.

For More Information

For technical information regarding the LIBS system, as well as pricing and purchasing information, please contact Robert De Saro of the Energy Research Company at (718) 608-8788 or rdesaro@er-co.com.

Project Partners

Energy Research Company
Staten Island, NY
(Prime)

Commonwealth Aluminum
Uhrichsville, OH

Oak Ridge National Laboratory
Oak Ridge, TN

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